

## Original

# Five year trends on total and abdominal adiposity in Spanish adolescents

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## Abstract

**Objective:** To assess five years trends in total and abdominal fat in Spanish adolescents.

**Design:** Two cross-sectional studies: adolescents from the city of Zaragoza (Spain) assessed during 2001-2002 and 2006-2007.

**Subjects:** 399 adolescents in 2001-02 and 392 adolescents in 2006-07.

**Main outcome measurements:** Socio-economic status was assessed using the education level of both parents. A complete anthropometric assessment was performed in both surveys using the same methodology: weight, height, skinfold thickness (biceps, triceps, subscapular, suprailiac, thigh and calf) and circumferences (waist and hip). The body mass index (BMI) and the sum of 6 skinfold thicknesses were calculated. Body fat percentage (BF%) was also calculated by the formulas described by Slaughter et al.

**Results:** After adjusting for age and pubertal status, only females showed a significantly decrease in weight, BMI and waist circumference, and a significant increase in the sum of 6 skinfolds (all  $P < 0.05$  and Cohen's  $d \geq 0.25$ ) in 2006-2007, when compared to values obtained in 2001-2002. Males did not show any significant change between the two surveys. Concerning centile values, a slight general reduction was observed in weight, BMI and waist circumference for both males and females. On the contrary, the sum of 6 skinfolds and the BF% were higher in 2006-2007 than in 2001-2002.

**Conclusion:** According to these results, there might be a levelling-off in the trends of BMI, BF% and waist circumference in male adolescents from Zaragoza. In females, despite a trend towards higher body fat mass, there was a trend towards lower BMI and waist circumference values.

(*Nutr Hosp.* 2012;27:731-738)

DOI:10.3305/nh.2012.27.3.5726

**Key words:** Abdominal fat. Adiposity. Adolescence. Body fat percentage. Secular trends.

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Recibido: 7-I-2012.  
1.ª Revisión: 11-I-2012.  
Aceptado: 17-I-2012.

## TENDENCIAS DURANTE CINCO AÑOS EN LA GRASA TOTAL Y ABDOMINAL EN ADOLESCENTES ESPAÑOLES

## Resumen

**Objetivo:** Evaluar las tendencias de cinco años de la grasa total y abdominal de adolescentes españoles.

**Diseño:** Dos estudios transversales: adolescentes de la ciudad de Zaragoza (España) evaluados durante 2001-2002 y 2006-2007.

**Sujetos:** 399 adolescentes en 2001-02 y 392 adolescentes en 2006-07.

**Principales variables estudiadas:** El estado socioeconómico se evaluó usando el nivel educativo de ambos progenitores. Se realizó una evaluación antropométrica completa en ambos estudios con la misma metodología: peso, talla, grosor del pliegue (bíceps, tríceps, subescapular, suprailíaco, muslo y pantorrilla) y circunferencias (cintura y cadera). Se calcularon el índice de masa corporal (IMC) y la suma del grosor de 6 pliegues. También se calculó el porcentaje de grasa corporal (%GC) con las fórmulas descritas por Slaughter et al.

**Resultados:** tras ajustar por edad y estado puberal, sólo las chicas mostraron un descenso significativo del peso, IMC y la circunferencia de la cintura, y un aumento significativo en la suma de los 6 pliegues cutáneos (todos ellos  $P < 0,05$  y  $d$  de Cohen  $\geq 0,25$ ) en 2006-2007, en comparación con los valores obtenidos en 2001-2002. Los chicos no mostraron cambios significativos entre ambos estudios. Con respecto a los percentiles, se observó una reducción leve del peso, IMC y circunferencia de la cintura en chicos y chicas. Por el contrario, la suma de los 6 pliegues cutáneos y el %GC fueron mayores en 2006-2007 que en 2001-2002.

**Conclusión:** de acuerdo con estos resultados, podría haber un resultado neutro en las tendencias del IMC, %GC y circunferencia de la cintura en los adolescentes varones de Zaragoza. En las chicas, a pesar de una mayor tendencia a una mayor grasa corporal, hubo una tendencia a unos menores valores de IMC y de circunferencia de la cintura.

(*Nutr Hosp.* 2012;27:731-738)

DOI:10.3305/nh.2012.27.3.5726

**Palabras clave:** Grasa abdominal. Adiposidad. Adolescencia. Porcentaje de grasa corporal. Tendencias seculares.

## Introduction

Overweight and obesity in children and adolescents has steadily increased over the last decades in the great majority of developed countries.<sup>1</sup> However, it has been recently reported that some areas showing high obesity rates started to level-off in its prevalence; this is the case for the United States, Sweden or France.<sup>2-4</sup> These studies assessed overweight and obesity using a surrogate marker of total body fat, namely, the body mass index (BMI). BMI is a useful tool for assessing the epidemiological situation; however, it has important limitations, especially in children and adolescents.<sup>5</sup> During childhood and adolescence, BMI seems to be more related with growth-related changes in fat free mass than with those in fat mass.<sup>6</sup> It also seems to be a good tool to identify those children with normal body fat levels, but not to those showing an excess of body fat.<sup>7</sup> In children and adolescents, total body fat can be estimated by measuring skinfold thickness.<sup>8</sup> In addition, waist circumference provides information about the amount of abdominal fat.<sup>9,10</sup>

Overweight and obesity are highly prevalent in Spanish children and adolescents,<sup>11,12</sup> and some studies have shown rising trends until the early 2000s.<sup>12,13</sup> In the framework of two multicenter studies, the AVENA [*Alimentación y Valoración del Estado Nutricional de los Adolescentes Españoles* (Food and Assessment of the Nutritional Status of Spanish Adolescents)] study in Spanish adolescents,<sup>14</sup> and the HELENA (Healthy Lifestyle in Europe by Nutrition in Adolescence) cross-sectional study (HELENA-CSS), in European adolescents,<sup>15</sup> we had the unique opportunity to perform a detailed anthropometry in adolescents from the city of Zaragoza (Spain), in these two surveys, one performed in 2001-2002 (the AVENA study) and the second one in 2006-2007 (the HELENA study). Therefore, the aim of our study was to assess five years trends in total and abdominal fat in comparable Spanish adolescents from Zaragoza.

## Population and methods

### *Population sample*

In this study we have considered two samples: 1) adolescents from the city of Zaragoza, assessed in the framework of the AVENA study, during 2001-2002;<sup>14</sup> 2) adolescents from the city of Zaragoza, assessed in the framework of the HELENA cross-sectional study (HELENA-CSS), during 2006-2007.<sup>15</sup> The sample size and selection were established using exactly the same methodology that has been described elsewhere.<sup>14-16</sup> In brief, BMI was used to estimate the sample size; because it was the studied variable with the highest variability. In both cases, a multiple step stratified random sample was obtained, in order to have a representative sample of the adolescents from the city of

Zaragoza. Strata were defined in terms of adolescent's age and sex and the type of school, as a way to select adolescents from all the socio-economic status strata. Written detailed information about the study was provided to the adolescents and their parents or guardians, and they signed an informed consent to participate in the study.<sup>17</sup>

### *Socio-economic status (SES)*

In both studies, socio-economic status was assessed using the education level of both parents.<sup>18</sup> With this information, a new variable called parental education was established, which included three levels. Parental education level 0 indicates that none of the parents achieved university degree; level 1 indicates that one of the parents achieved university degree; level 2 indicates that both parents achieved university degree.

### *Anthropometric assessment*

A complete anthropometric assessment was performed in both surveys using exactly the same methodology. In both surveys, measurements were done by the same well trained researchers. Intra-observer reliability in both, AVENA and HELENA surveys, was always higher than 95%, and inter-observer reliability higher than 90%.<sup>19,20</sup>

Weight was measured in underwear and without shoes with a scale (SECA 861) to the nearest 0.1 kg, and height was measured barefoot in the Frankfurt plane with a telescopic height measuring instrument (SECA 225) to the nearest 0.1 cm. BMI was calculated as body weight (without shoes) divided by the square of height in meters.

Skinfold thickness and circumferences were measured three times, but not consecutively; they were measured in order, and then the same measurements were repeated two more times. A set of skinfold thicknesses (biceps, triceps, subscapular, suprailiac, thigh and calf) and circumferences (waist and hip) were measured on the left side of the body, with a Holtain calliper (Crymmych, UK) to the nearest 0.2 mm and with a non-elastic tape to the nearest 0.1 cm, respectively.<sup>20</sup>

As an index of total adiposity, we calculated the sum of the 6 measured skinfold thicknesses (sum of 6 skinfolds). Body fat percentage (BF%) was also calculated by the formulas described by Slaughter et al.<sup>21</sup> These equations showed the best agreement with total body fat percentage measured by DXA in those adolescents from Zaragoza included in the AVENA study.<sup>22</sup>

### *Sexual maturation*

Physical examination was performed by a physician aiming to classify the adolescents in one of the five

stages of pubertal development defined by Tanner and Whitehouse.<sup>23</sup>

### *Statistical analysis*

The data are presented as mean  $\pm$  SD unless otherwise stated. Gender differences for each survey were assessed by one-way analysis of variance (ANOVA). Mean differences of the secular trends in body composition (i.e., weight, BMI, sum of 6 skinfolds, waist circumference and BF%) between measurement points were analysed by one-way analysis of covariance (ANCOVA) for males and females separately. The measurement point was entered as fixed factor, every body fat indicator was entered as dependent variable, and age and pubertal status were entered as covariates. We calculated the effect size statistics as Cohen's *d* (standardized mean differences) and 95% confidence interval.<sup>24</sup> Adolescents were split into centiles by their body composition indicators to show graphically the differences between the measurement points. The analyses were performed using the Statistical Package for Social Sciences (SPSS, v. 16.0 for WINDOWS; SPSS Inc, Chicago) and the level of significance was set at  $< 0.05$ .

### *Ethics Committee approval*

Both studies were performed following the ethical guidelines of the Declaration of Helsinki 1961 (revision of Edinburgh). The study protocols were approved by the Review Committee for Research Involving Human Subjects of the Hospital Universitario Marqués de Valdecilla (Santander, Spain) and by the Research Ethics Committee of the Government of Aragón (CEICA; Spain), for the AVENA study and the HELENA-CSS, respectively.

## **Results**

The characteristics of the study population by survey (2001-2002 and 2006-2007) and gender are shown in table I. We included in this study 399 adolescents in 2001-02 and 392 adolescents in 2006-07. Females had higher levels of BF% (all  $P < 0.001$ ) than males in both surveys. Table II shows the mean of body composition indicators by gender in both measurement points. After adjusting for age and pubertal status, only females showed a significantly decrease in weight, BMI and waist circumference, and a significant increase in the sum of 6 skinfolds (all  $P < 0.05$  and Cohen's *d*  $\geq 0.25$ ) compared to values obtained in 2001-2002. We repeated all the analyses after further adjusting for parental education and the results did not materially change. The centile values of the weight, BMI and sum of 6 skinfolds (fig. 1) and waist circumference and the BF%

(fig. 2) are graphically depicted according to gender and measurement point. A slight general reduction was observed in weight, BMI and waist circumference but results were only significant in females. On the contrary, the sum of 6 skinfolds and the BF% were higher in 2006-2007 when compared with values obtained in 2001-2002.

## **Discussion**

The main finding of our study was that weight, BMI and waist circumference decrease from 2001-2002 to 2006-2007, but these changes were only significant in females. In contrast, both the sum of 6 skinfolds and BF% increased during the same period in females. It is important to highlight that only the changes in the sum of 6 skinfolds were statistically significant.

In previous reports in children and adolescents from our region, we observed trends towards an excess of total and regional fat deposition.<sup>25-28</sup> We observed a significant trend in overweight prevalence from 1985 to 1995 in children from the first primary school year (6-7 years); whereas in children in the last primary school year (13-14 years) there was a significant trend only in males.<sup>25</sup>

In two cross-sectional surveys conducted in Zaragoza, in 1980 and 1995, in children aged 6 to 15 years, BF% significantly increased in all age groups, with increases ranging from 2.46% at 13.5 years to 6.03% at 11.5 years.<sup>26</sup> In the same cohort, we also calculated some indices of fat patterning, derived from skinfold thickness measurements; in males, we observed a significant trend to a central pattern of fat distribution at the ages of 6.5-11.5 y. In females, we also observed a significant trend to a central pattern of fat distribution but only at the ages of 6.5 and 7.5 y.<sup>27</sup> Finally, two studies, in 1995 and 2000-02, were compared to assess changes in waist circumference in adolescents. Waist circumference increased significantly in males at 13 years and in females at 14 years.<sup>28</sup> All these studies<sup>25-28</sup> showed a trend towards high total and regional fat deposition, as it has also been shown in the great majority of the regions all over the world.<sup>1</sup>

We have found a decrease in body weight and BMI along the years, although statistically significant only in females. This finding concurs with some recent studies reporting on a levelling-off or stabilization tendency on the prevalence of overweight and obesity.<sup>2-4</sup> In US children and adolescents, Ogden et al.<sup>2</sup> observed that the prevalence of high BMI for age did not increase either between 2003/04 and 2005/06 or between 1999 and 2006.

A population-based study of 10-year-olds from the Stockholm County also showed that rates of obesity, overweight and underweight were stable from 1999 to 2003.<sup>3</sup> Strong gradients, with more obesity and overweight in socioeconomically disadvantaged areas, were observed in both genders in 2003. Differences

**Table I**  
*Characteristics of the study samples by measurement point and gender*

	Years 2001-02				Years 2006-07			
	<i>n</i>	<i>Males</i>	<i>Females</i>	<i>All</i>	<i>n</i>	<i>Males</i>	<i>Females</i>	<i>All</i>
Age (years)	399	15.1 ± 1.2	15.1 ± 1.3	15.1 ± 1.2	392	14.8 ± 1.3	14.8 ± 1.1	14.8 ± 1.2
Tanner stage (%) I/II/III/IV/V	361	0.0/4.3/11.8/ 41.0/42.9	0.0/0.0/2.0/ 48.0/50.0	0.0/1.9/6.4/ 44.9/46.8	378	0.0/4.3/9.7/ 19.9/66.1	0.0/0.5/5.2/ 5.7/88.6	0.0/2.4/7.4/ 12.7/77.5
Weight (kg)	379	62.9 ± 13.1**	55.6 ± 8.3	59.0 ± 11.4	392	61.6 ± 13.0**	54.4 ± 9.1	57.9 ± 11.7
Height (cm)	379	169.8 ± 8.5**	161.2 ± 6.1	165.2 ± 8.5	392	169.2 ± 10.0**	160.1 ± 7.1	164.6 ± 9.8
BMI (kg/m <sup>2</sup> )	379	21.7 ± 3.5	21.4 ± 2.9	21.5 ± 3.2	392	21.4 ± 3.5	21.2 ± 3.2	21.3 ± 3.3
Skinfolds thickness (mm)								
Bicipital	380	7.2 ± 4.2**	8.9 ± 3.4	8.1 ± 3.9	391	8.0 ± 4.9**	10.5 ± 3.9	9.2 ± 4.6
Tricipital	380	12.8 ± 7.2**	16.7 ± 5.5	14.9 ± 6.6	392	13.3 ± 6.8**	18.2 ± 5.9	16.8 ± 6.8
Subscapular	380	11.8 ± 6.5**	13.8 ± 5.5	12.9 ± 6.1	391	12.6 ± 7.5**	15.4 ± 6.7	14.0 ± 7.3
Suprailiac	380	11.3 ± 7.0**	12.3 ± 5.0	11.8 ± 6.0	392	13.0 ± 8.4**	17.0 ± 7.7	15.1 ± 8.3
Thigh	379	16.9 ± 7.8**	24.5 ± 5.5	21.0 ± 7.6	380	19.4 ± 8.8**	27.1 ± 7.4	23.3 ± 9.0
Calf	379	13.0 ± 7.3**	17.2 ± 5.6	15.2 ± 6.8	388	15.2 ± 7.7**	20.2 ± 6.4	17.7 ± 7.5
Sum of six	379	72.9 ± 38.1**	93.4 ± 26.9	83.9 ± 34.1	377	79.6 ± 39.2**	106.4 ± 31.9	93.1 ± 38.1
Waist circumference (cm)	380	76.8 ± 9.4**	72.3 ± 6.9	74.4 ± 8.5	391	75.6 ± 9.5**	71.5 ± 7.6	73.6 ± 8.8
Hip circumference (cm)	380	92.8 ± 8.5	93.8 ± 6.3	93.3 ± 7.4	389	92.4 ± 8.7*	94.4 ± 7.1	93.4 ± 8.0
Waist/hip ratio	380	0.83 ± 0.05**	0.77 ± 0.04	0.80 ± 0.05	389	0.82 ± 0.05**	0.76 ± 0.05	0.79 ± 0.06
Waist/height ratio	379	0.45 ± 0.05	0.45 ± 0.04	0.45 ± 0.05	391	0.45 ± 0.06	0.45 ± 0.05	0.45 ± 0.05
Slaughter's body fat (%)	367	20.1 ± 11.3**	25.6 ± 6.3	23.1 ± 9.3	386	20.9 ± 11.7**	27.4 ± 7.0	24.2 ± 10.1
Fat mass (kg)	366	13.5 ± 10.5**	14.6 ± 5.8	14.1 ± 8.2	386	13.8 ± 10.1**	15.3 ± 6.2	14.6 ± 8.4
Fat free mass (kg)	366	49.0 ± 8.1**	41.0 ± 4.2	44.6 ± 7.4	386	47.8 ± 8.6**	39.9 ± 4.3	43.3 ± 8.1
Parental education (%) Level 0/Level 1/Level 2	310	69.9/21.0/9.1	72.4/17.4/10.2	71.3/19.0/9.7	359	100.0/0.0/0.0	100.0/0.0/0.0	100.0/0.0/0.0

Values are mean ± standard deviation, unless otherwise indicated.

\*P ≤ 0.05 and \*\*P ≤ 0.001 for gender comparisons. Parental education level 0 indicates that none of the parents achieved university degree; Level 1 indicates that one of the parents achieved university degree; Level 2 indicates that both parents achieved university degree.



**Table II**  
*Body composition measurements by time point and gender*

	Body composition indicator	n	Year 2001-02	n	Year 2006-07	p	Cohen's d	95% CI for d
Males	Weight (kg)	161	62.7 ± 11.7	186	60.8 ± 11.7	0.131	0.16	-0.048 to 0.374
	BMI (kg/m <sup>2</sup> )	161	21.6 ± 3.5	199	21.3 ± 3.6	0.323	0.11	-0.102 to 0.312
	Sum 6 skinfolds (mm)	161	72.1 ± 38.9	180	79.4 ± 38.8	0.088	0.19	-0.027 to 0.399
	Waist circumference (cm)	161	76.8 ± 9.6	185	75.5 ± 2.9	0.216	0.13	-0.078 to 0.346
	Fat mass (%)	161	19.7 ± 11.4	186	20.8 ± 5.0	0.370	0.10	-0.114 to 0.308
Females	Weight (kg)	199	56.3 ± 8.4	192	53.4 ± 8.4	0.001	0.33	0.135 to 0.535
	BMI (kg/m <sup>2</sup> )	186	21.7 ± 2.9	192	20.9 ± 3.0	0.011	0.26	0.060 to 0.467
	Sum 6 skinfolds (mm)	199	95.6 ± 29.6	183	104.1 ± 29.7	0.007	0.28	0.074 to 0.478
	Waist circumference (cm)	200	72.9 ± 7.3	192	71.0 ± 7.3	0.013	0.25	0.053 to 0.452
	Fat mass (%)	200	26.2 ± 6.7	191	26.8 ± 6.7	0.398	0.09	-0.113 to 0.285

Values are mean ± standard deviation.

P values from one-way analysis of covariance after adjusting for age and pubertal status.

between socio-economic status areas were also seen in 1999 but were more pronounced in 2003. Among boys, divergent trends in obesity were observed between 1999 and 2003, with evidence for increases in less affluent areas only.<sup>3</sup>

In children aged 6-to 15-years measured at health examination centres in the central/western part of France between 1996 and 2006, overweight prevalence increased between 1996 (11.5%) and 1998 (14.8%). Similarly, in the low socio-economic status group, it increased between 1996 (12.8%) and 2001 (18.9%) and also stabilized between 2001 and 2006 (18.2%). This stabilization coincides with increasing information on childhood overweight in France, and the launching of the National Plan on Nutrition and Health in 2001.<sup>4</sup> There was no effect of parental education in the observed trends in our population.

In our study, females showed a significant increase in the sum of 6 skinfolds. This result seems to contradict the observed decrease in weight and BMI in our own sample. However, in terms of body composition, the observed changes in weight and BMI could be partly due to changes in fat free mass and not necessarily to changes in fat mass. This is not surprising given that in children and adolescents BMI is more related to fat free mass than to fat mass and changes in BMI seems to be more related with the growth-related changes in fat free mass than with those in fat mass.<sup>6,29</sup> In support of this hypothesis, we observed in a previous report from the same two cohorts, that muscular strength increased from 2001/02 to 2006/07,<sup>30</sup> and it is known that muscular strength components are associated with fat-free mass.<sup>31</sup> It could also be argued that time spent in sedentary activities probably could have increased in the last years; however, no information in this regard is available in our population.

There are few studies assessing trends in body fat composition using complete anthropometry. Watkins

et al.<sup>32</sup> examined secular trends using measures of fatness over a 10-y period (1989-1990, and 1999-2001) in 12-and 15-years-old Northern Irish school-children. Body fat percentage was derived from skinfolds measurement at four sites. Increases in mean BMI (19.2-20.3 kg/m<sup>2</sup>) and mean BF% (25.8-27.1%) were only seen in 12-y-old girls, with no significant changes in any of the other age subgroups. In a previous study in the city of Zaragoza, we observed a trend towards higher BMI value from 1980 to 1995 that was parallel to an increase in BF% assessed by the measurement of skinfold thickness.<sup>26</sup> The results reported in this paper seem to show that, in the last years, there is, at least in males, a levelling-off in the body fat composition changes.

Waist circumference can be considered a good marker of visceral abdominal tissue.<sup>33</sup> There are also few studies assessing trends in abdominal fat using waist circumference. McCarthy et al.<sup>34</sup> reported that central fatness in young British children increased over the period of 1987-97 to a greater extent than general fatness assessed with BMI. In contrast, in our study we observed a trend towards lower waist circumference values that was equivalent to the trends in BMI. In adolescents from Zaragoza, we also observed in 1995 and 2000/02, that waist circumference increased significantly in males at 13 years and in females at 14 years.<sup>28</sup> The rates of change were 0.53 and 0.86 cm/y in boys and 0.67 and 0.87 cm/y in girls. The rate of decrease in our study was equivalent to the previously reported increase (0.58 cm/y).

Strengths of our study are the complete assessment of body composition using anthropometry in a relative large sample of adolescents from Zaragoza, Spanish city in which we have monitored body composition trends for several decades. In addition, the measurements were performed by the same research team, following strict standardization procedures. Limita-

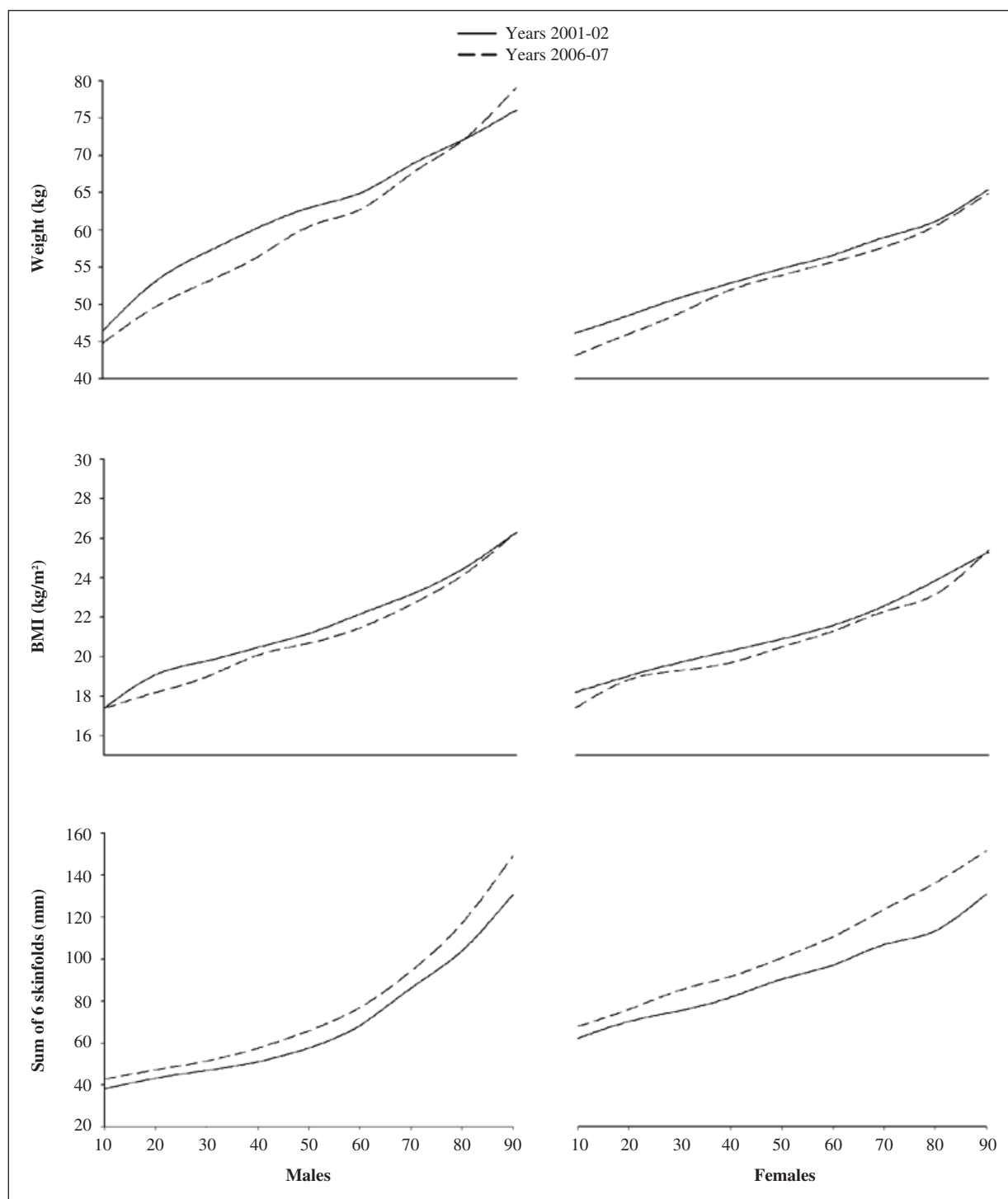


Fig. 1.—Centile values of weight, BMI and sum of 6 skinfolds according to gender and measurement point.

tions of the study are that the results can not be extrapolated to a large population; however, they can be indicative of the trends that may occur in the full Spanish population, as Zaragoza is considered as a representative city of the whole country.

In conclusion, there is a levelling-off in the trends of BMI, BF% and waist circumference in male adolescents from Zaragoza. In females, despite a trend

towards higher body fat mass, there is a trend towards lower BMI and waist circumference values. Discrepancies in the results could be explained by the fact that changes in BMI during childhood and adolescence are parallel to changes in fat-free mass more than to changes in fat mass. Further studies are necessary to confirm these findings, if possible in large national representative samples.

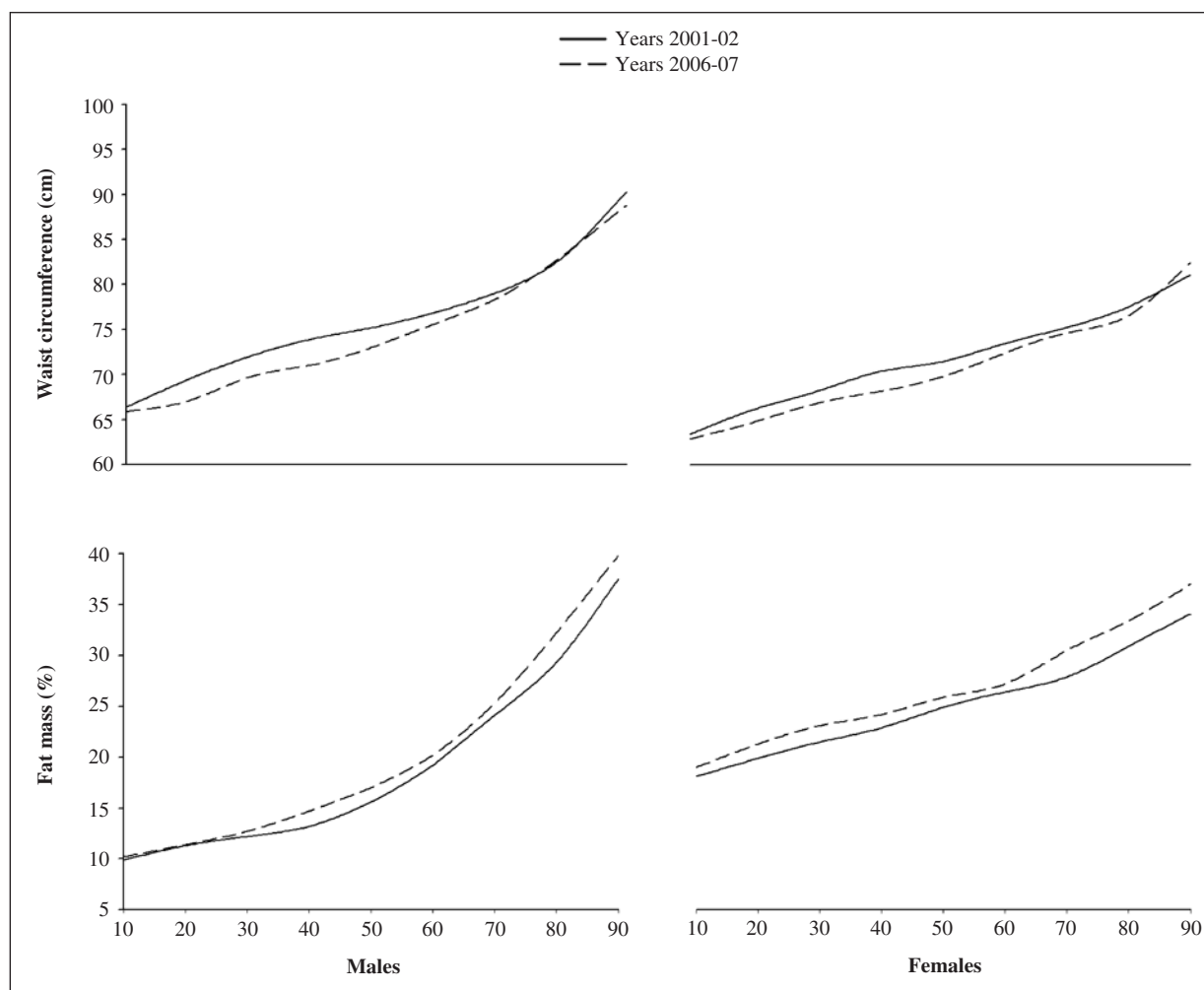


Fig. 2.—Centile values of waist circumference and body fat percentage according to gender and measurement point.

## Acknowledgements

The authors express their sincere gratitude to the adolescents who participated in the AVENA and HELENA studies. The AVENA Study was supported by the Spanish Ministry of Health, FIS (00/0015) and grants from Panrico S.A., Madaus S.A. and Procter & Gamble S.A. The HELENA Study was carried out with financial support of the European Community Sixth RTD Framework Programme (Contract FOOD-CT-2005-007034). This study was also supported by the Spanish Ministry of Education (EX-2007-1124, EX-2008-0641, DEP2007-29933-E, AP2006-02464). LAM, MIM, GVR, GR, JF, and MGF were also supported by a grant from the Spanish Ministry of Health: Maternal, Child Health and Development Network (number RD08/0072).

## What is already known on this topic

Overweight and obesity in children and adolescents have increased over the last decades in the great majority of developed countries.

It has been recently reported that some areas showing high obesity rates started to level-off in its prevalence.

Studies assessed overweight and obesity using a surrogate marker of total body fat, namely, the body mass index.

## What this study adds

In male Spanish adolescents there might be a leveling-off in the trends of body mass index, body fat percentage and waist circumference.

In females, despite a trend towards higher body fat mass, there was a trend towards lower body mass index and waist circumference.

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